sciendo

Ekológia (Bratislava) - Journal of the Institute of Landscape Ecology, Slovak Academy of Sciences Vol. 41, No. 3, p. 236–246, 2022

DOI:10.2478/eko-2022-0024

PREDICTING SUITABLE HABITATS OF THE MAJOR FOREST TREES IN THE SAÏDA REGION (ALGERIA): A RELIABLE REFORESTATION TOOL

MOHAMMED DJEBBOURI[1], MOHAMED ZOUIDI ✉ [2], MOHAMED TERRAS[1], ABDELAZIZ MERGHADI[2]

[1]Laboratory of Water Resources and Environment, Department of Biology, Faculty of Science, University of Saida – Dr. Tahar Moulay, Algeria; e-mail: mohammeddjebbouri@yahoo.com; mohamedterras@hotmail.com

[2]Territory Planning Research Center (CRAT) Constantine – Algeria; e-mail: zouidibiologie20@gmail.com, mohamed.zouidi@crat.dz, abdelaziz.merghadi@gmail.com

✉ Corresponding author

Received: 3.10.2021 / **Accepted:** 25.1.2022

Abstract

Djebbouri M., Zouidi M., Terras M., Merghadi A.: Predicting suitable habitats of the major forest trees in the Saïda region (Algeria): A reliable reforestation tool. Ekológia (Bratislava), Vol. 41, No. 3, p. 236–246, 2022.

Modeling potential habitat for plant species is an appropriate approach to maintain biodiversity, developing proper reforestation campaigns, and rehabilitating ecosystems. In this study, we investigated the potential distributions of four forest species, namely, *Quercus faginea* Lam.; *Q. ilex* L.; *Tetraclinis articulata* (Vahl) Mast.; and *Pistacia atlantica* Desf. In the north-western Algeria at Saïda region. The MAXENT method was used to model the habitats of these species using topographic data as predictive variables at a resolution of 100 m. Moreover, the model evaluation process was achieved using the area under the operating characteristic curve of the receiver (AUC) and Jackknife test.
The generated models were found to be accurate. AUC results are ranging between 0.98 and 0.91 for the training set and 0.87 and 0.97 for the testing set. The results of the distribution probability of this study provide a useful tool for the local decision-makers of reforestation campaigns.

Key words: Spatial Distribution Model, MAXENT, reforestation, Saïda, topographic variables.

Introduction

Reforestation and ecological restoration programs initially recommend local species implantation (Society for Ecological Restoration International Science & Policy Working Group, 2004). However, in Algeria, a wooded area of over 3 million ha has been reforested by the Aleppo pine instead of its native species such as *Quercus faginea* Lam*; Q. ilex* L.*; Tetraclinis articulata* (Vahl) Mast; and *Pistacia atlantica* Desf (Brague-Bouragba et al., 2007). In fact, solving this issue mandate trying to understand the most conducive approach to the growth of a given species in given areas. As result, species distribution models (SDMs) can be a useful approach to solve this. In general, SDM can be defined as the predicted distribution of species in the landscape according to the relationship between the presence of the species and environmental variables (Guisan et al., 2002). However, various SDMs exist such as CLIMEX, Genetic Rule Set Generation (GARP) algorithm, and Maximum Entropy (MAXENT). Each of these SDMs can be successfully used to assess distribution areas and ecological requirements and/or responses (Guisan, Thuiller, 2005; Phillips et al., 2006; Phillips, Dudík, 2008). Yet, each of the SDMs serves a purpose; MAXENT was proven to outperform other SDMs if small samples are used (Elith et al., 2006; Kumar, Stohlgren, 2009; Pearson et al., 2007). However, it is important to note that details and quality influence the overall SDM. For example, high-resolution topographic data (i.e., reflect local ecological conditions) are able to generate better predictive model. On the hand, low-resolution data are able to generate smoother environmental gradients in the large-to-medium scale (Zhang et al., 2016). DEMs and their derived topographic indices (e.g., slope, aspect, and topographic wetness index) are routinely calculated using geographic information systems (GIS) and are widely used as surrogates for a variety of environmental variables measured in the field such as temperature, incoming solar radiation, and soil moisture (Hengl, Reuter, 2008), and have long been used for a wide range of studies in ecology (Leempoel et al., 2015; Lecours et al., 2016; Zhang et al., 2016). This is becoming a common practice in SDM ecological modeling (Lassueur et al., 2006; Mod et al., 2016; Zhanget al., 2016), as it is strongly correlated with temperature, precipitation, moisture, soil nutrients, and geomorphological processes (Agnew, Palutikof, 2000; Das et al., 2015; Leempoel et al., 2015; Ayache et al., 2020).

As a result, in this study, we were able to model the spatial distributions of four forest species (i.e., *Quercus faginea* Lam. *Q. ilex* L., *Tetraclinis articulata* (Vahl) Mast., *Pistacia atlantica* Desf) in the Saida region, based on topographic predictors derived from DEM, with the interest of obtaining a relatively high-resolution distribution map (≈100m), which can be used in the management and reforestation programs.

© The Author(s) 2022. This is an open access article licensed under the Creative Commons Attribution-NonCommercial-NoDerivs License (http://creativecommons.org/licenses/by-nc-nd/3.0/).

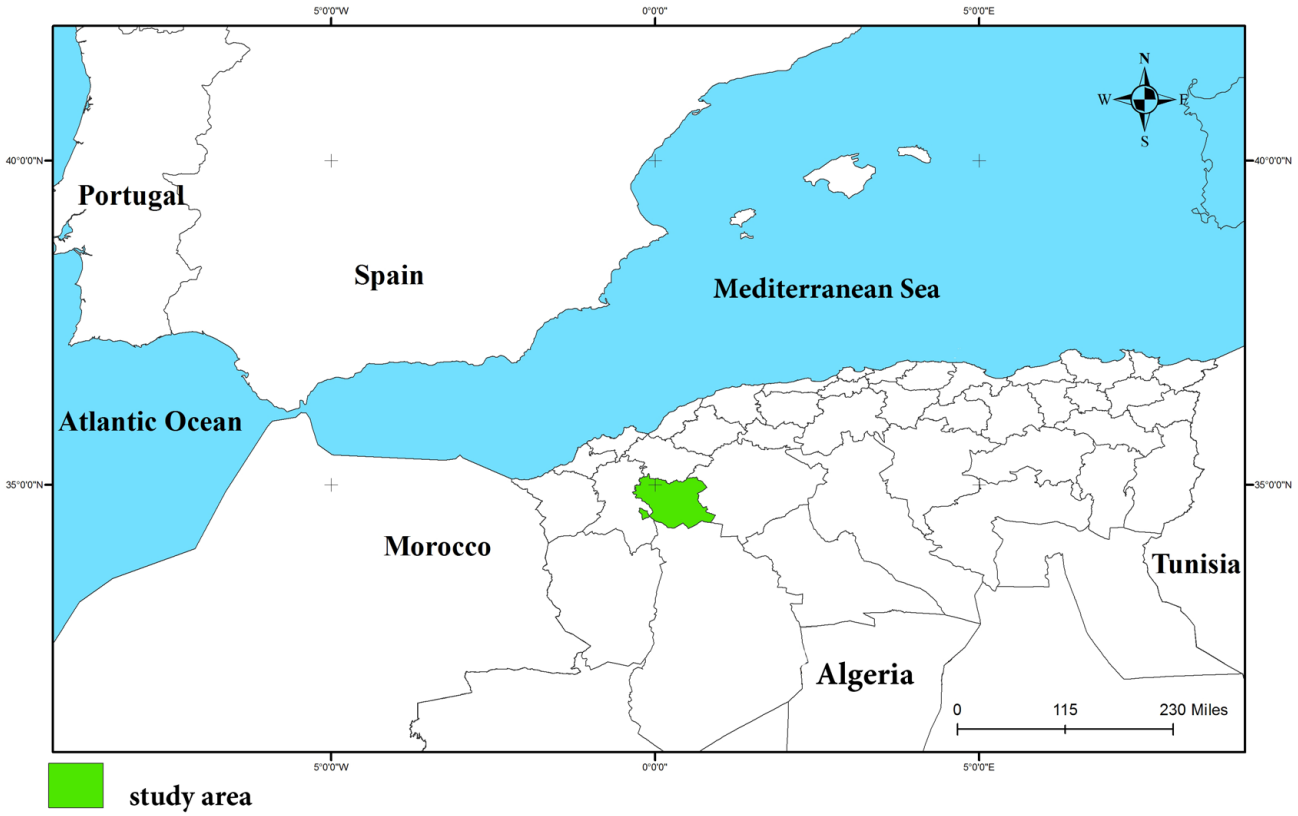


Fig. 1. Geographical situations of study areas.

Material and methods

Study area

The study area is located in northwestern Algeria, covers a total area of 6,765 km^2 this territory frame in space is defined by latitudes 34°31› to 35°16›N and by longitudes 0°34› to 0°93›E. The altitude varies between 323.5 and 1,348.2 m (Fig. 1).

According to the phytoecological studies carried out by several researchers in this region, it has been possible to give an average floristic composition fairly representative of the different plant groups. The forest ecosystem covers more than 26% of the total surface, a rate higher than the national average imposing a forestry vocation on the area. The state forests of Tendfelt, Djaafra, and Fenouane are the most important; they are dominated by the Aleppopine groups and the Holm oak grouping followed by the Oleo-lenisque grouping and the *Tetraclinis articulata* grouping (Terras, 2011: Djebbouri, Terras, 2019).

According to available data from the nearest climatological station (Rebahia station), for a period of 30 years from 1985 to 2015, the annual rainfall is about 361 mm year^{-1}. The mean maximum temperature in the warmest months (July and August) and the lowest average temperature in the coldest months (January and February) were 27 and 3°C, respectively. The climate in the study area is semi-arid Mediterranean; the seasonal regime of the zone is of the WASS type (winter, autumn, spring, and summer) with a dry period of almost 6 months from May to October (Zouidi et al., 2019).

Table 1. Number of presence locations of target species used for MAXENT analysis.

Species	Number of records registered
Pistacia atlantica	33
Qurecus faginea	23
Qurecus ilex	44
Tetraclinis articulata	32

The study area is characterized by a nonnegligible forest surface in the order of 174,361 ha, that is, 26.17% of the total area of which more than 59.67% are concentrated on 6 communes located on the Daïa Mountains and the Saïda Mountains (Terras, 2011; Djebbouri, Terras, 2019).

Sampling of target species

Data collection in the field of natural populations spans over three years, between 2016 and 2018 in the region of Saida. A total of 132 geographic locations (geographic coordinates) of the presence points of the target species (*Pistacia atlantica, Quercus faginea, Q. ilex*, and *Tetraclinis articulata*) were recorded in the study area (Table 1, Fig. 2), where only single species record is kept in each single raster (i.e., spatial filtering to avoid pseudo

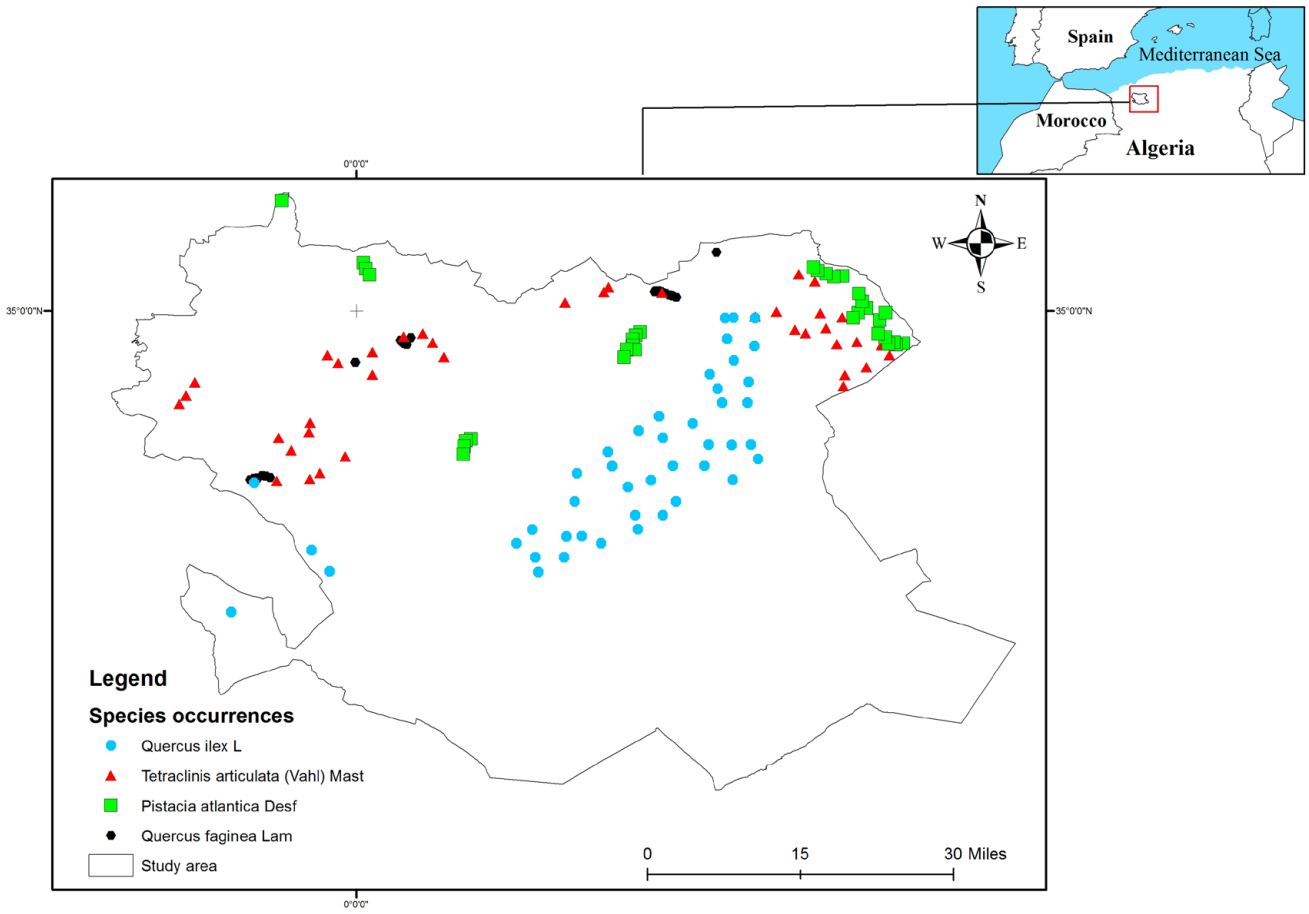


Fig. 2. Species occurrences.

Table 2. The selected variables.

Code	Unit	Variables
Al	Meter	Altitude
DM	Meter	Distance to Mediterranean sea
Cas	Dimensionnels	Northern exposure = cos(aspect)
Sas	Dimensionnels	Eastern exposure =sin(aspect)
SD	Meter	Distance to streams
SL	Radians	Slope
TC	Radians/meter	Total curvature
TPI	Meter	Topography position index

Table 3. MAXENT model parameter settings.

Hyperparameters	Value
Maximum number of background points	10,000
Convergence threshold	0.00001
Regularization multiplier	1
The maximum number of iterations	5000

replication) (Fourcade et al., 2014; Giles et al., 2014; Khosravi et al., 2016).

Topographic data

The topographic variables used in the implement MAXENT model were of 100 m resolution and derived from the digital terrain model (DTM) provided by the USGS. The derived topographic variables were calculated using SAGA GIS and ArcGIS 10.3 (Table 2). Thedistance to the Mediterranean sea (coastline) and distance to streams was calculated using the Euclidean distance function of ArcGIS software (Hardlife et al., 2020; Laala et al., 2021) and tested for correlations between using the SDM Toolbox (Hamdi et al., 2020).

Modeling procedure

In this study, the MAXENT model was generated by MAXENT software (version 3.3.3) using a set hyperparameters (Table 3) with 75% of the data reserved for model training, while the remaining 25% was reserved for model testing and validation.

Furthermore, according to Abolmaali et al. (2018), the Jackknife analysis was used to assess the importance of variables

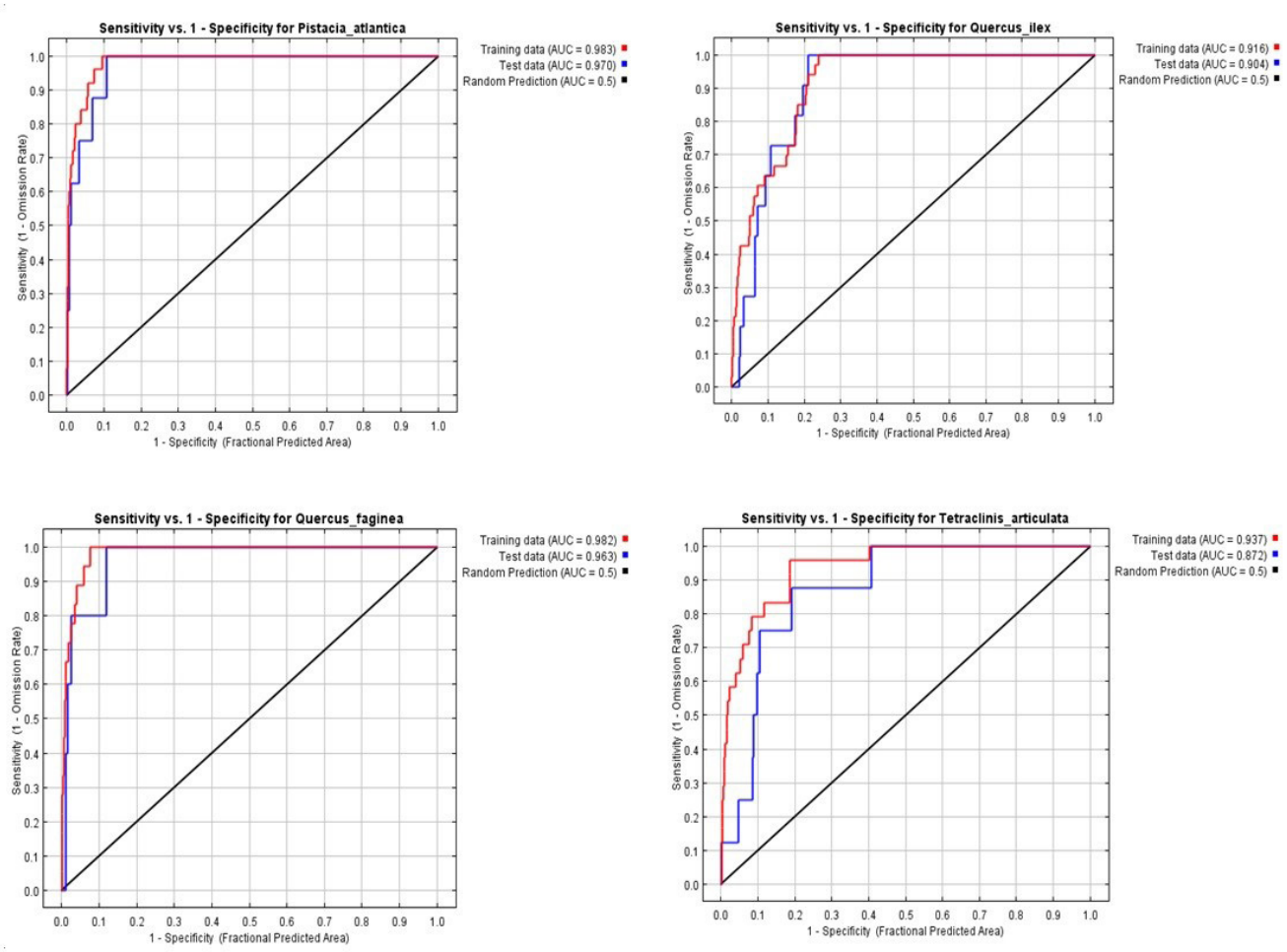


Fig. 3. ROC curves for the considered tree species.

used in the model. In general, Jackknife test produces a set of curves that represent the relationships between environmental factors and the probability of occurrence of the species. They demonstrate biological tolerances and habitat preferences for each species. Moreover, in order to evaluate the performance of the MAXENT model, the area under the receiver operator curve (AUC) metric was used and the values vary between 0 and 1, and the values can be interpreted as follows: AUC > 0.90 is Excellent; 0.8≤ AUC ≤ 0.90 is Good; 0.7≤ AUC ≤ 0.8 is Acceptable; 0.6≤ AUC ≤ 0.70 is Bad; AUC < 0.60 is Invalid.

Suitability map

MAXENT produced probability raster (i.e., values ranging from 0 to 1) of the potential presence of the species, representing habitat suitability. In the present study, a cut threshold of 10% of was applied. This allows to select values above the cut threshold which means that 90% of the training samples are correctly classified. Furthermore, the suitability map was obtained by reclassifying the probability raster into categories on the basis of Abrha et al. (2018).

Table 4. Correlation matrix of selected variables.

	Al	DM	Cas	Sas	SD	SL	TC	TPI
Al	1.00							
DM	0.66	1.00						
Cas	-0.08	-0.10	1.00					
Sas	0.02	0.03	0.03	1.00				
SD	0.03	-0.17	-0.02	0.00	1.00			
SL	-0.15	-0.22	0.03	0.00	0.17	1.00		
TC	-0.02	0.05	0.00	0.00	0.04	0.32	1.00	
TPI	0.05	0.00	0.00	0.00	0.01	0.02	0.07	1.00

Results and discussion

The results of the correlation matrix among variables (Table 4) show that the variables used in MAXENT model are safe to use (i.e., independent from each other and does not correlate), because all the correlation coefficients were below the recommended threshold of 0.7 (Merghadi et al., 2020).

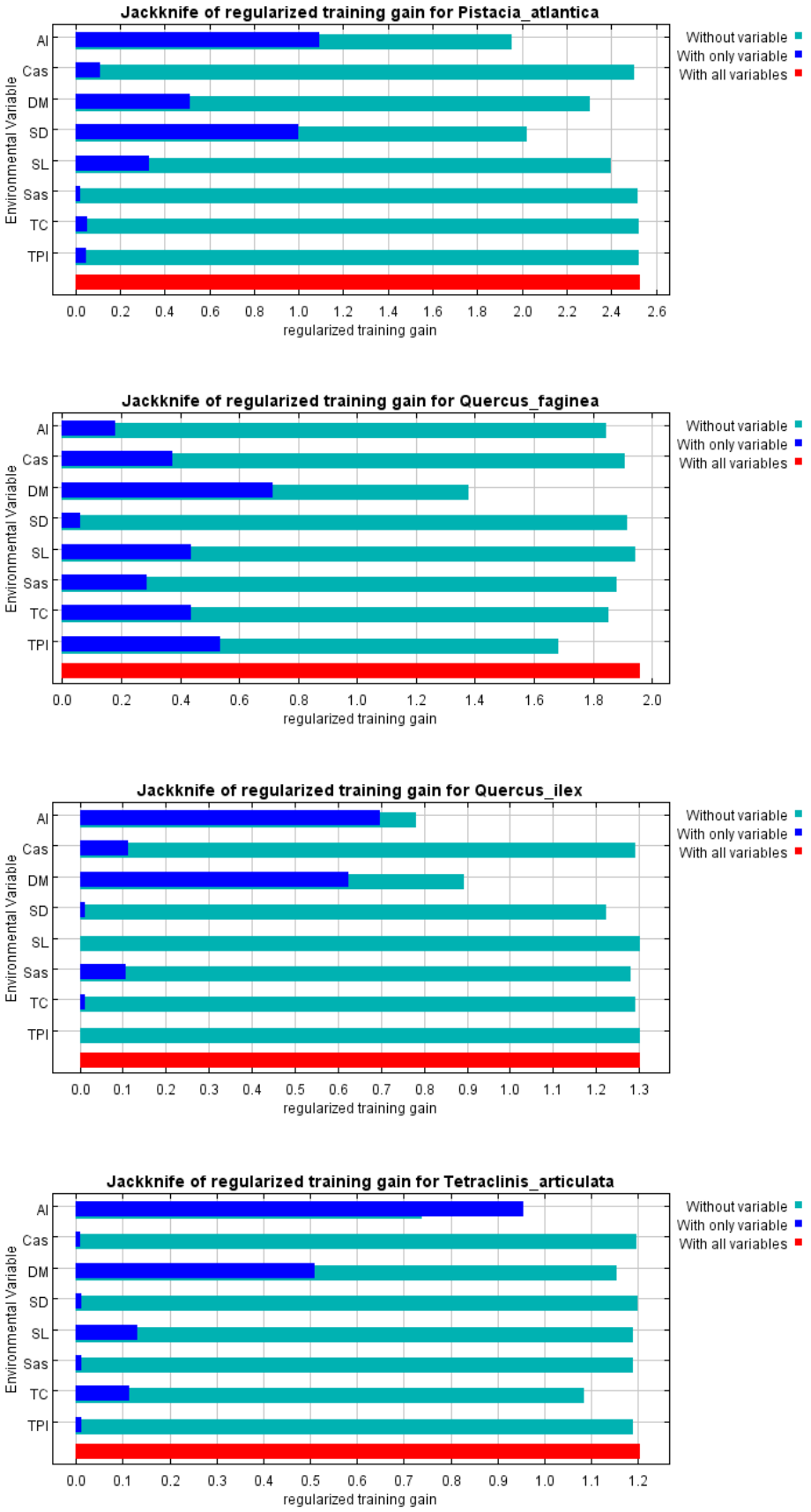


Fig. 4. Relative predictive power of different variables based on the jackknife of regularized training gain in MAXENT models for *Pistacia atlantica* (A), *Quercus faginea* (B), *Q. ilex* (C), and *Tetraclinis articulate* (D).

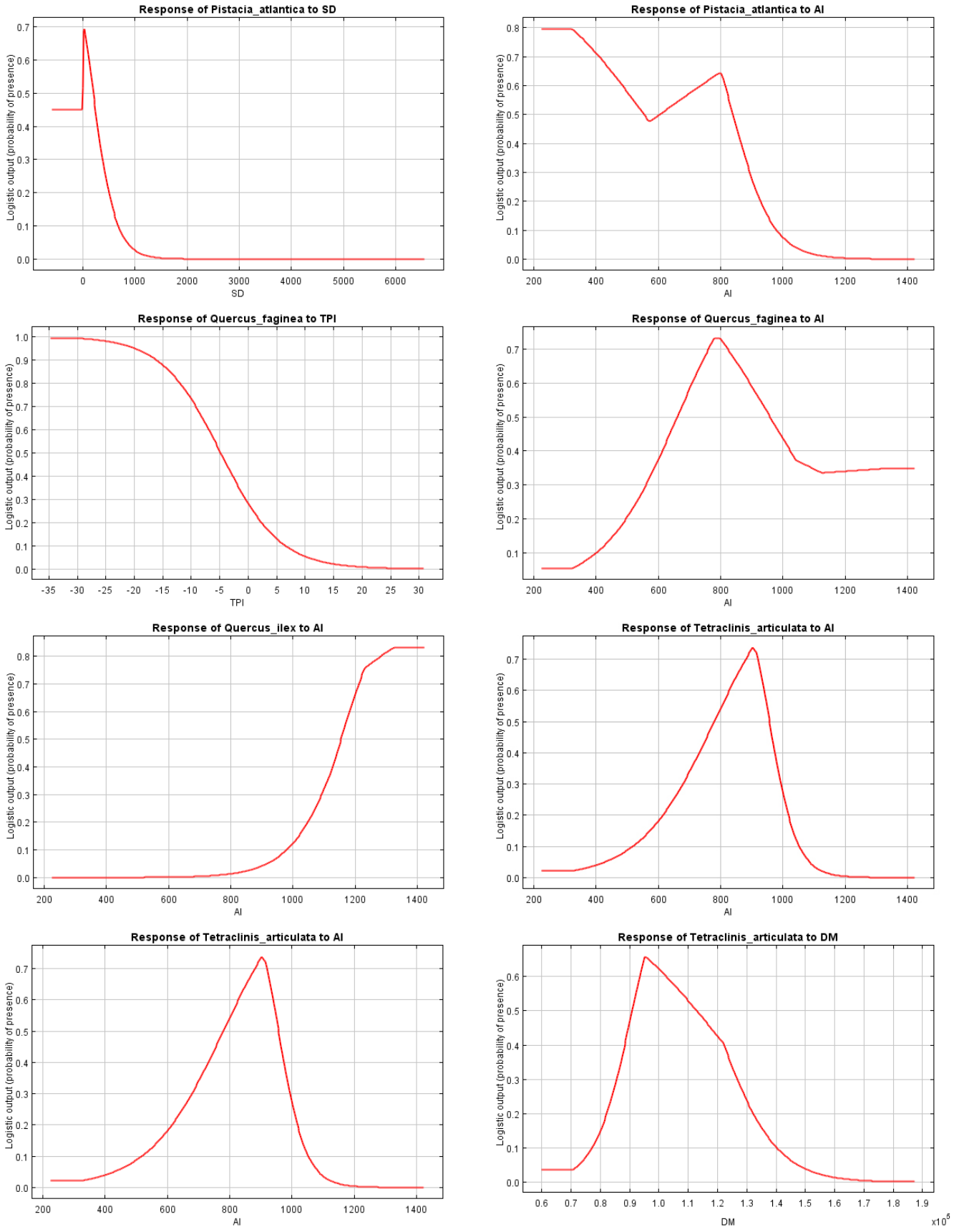


Fig. 5. Response curves of the most influential predictors for the four study species.

Table 5. Suitability threshold.

	Unsuitable area	Less suitable area		Suitable area
Pistacia atlantica	0.2278	0.2278 - 0.4556		0.4556- 1
Qurecus faginea	0.3220	0.3220 - 0.644		0.644 - 1
Qurecus ilex	0.2574	0.2574 - 0.5148		0.5148- 1
Tetraclinis articulata	0.3014	0.3014 - 0.6028		0.6028-1

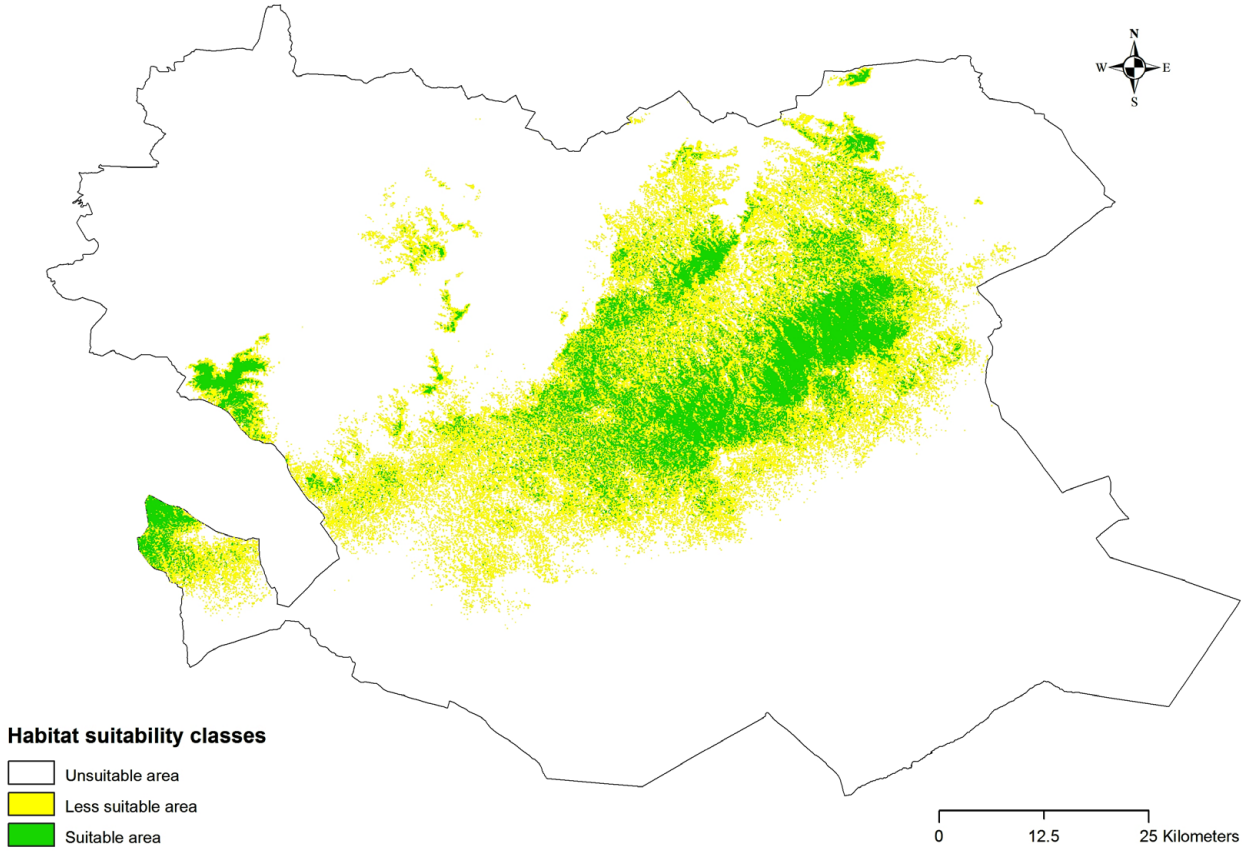


Fig. 6A. Potential habitat map of *Quercus ilex*.

The AUC of ROC values for the four species is shown in Figure 3. The generated models based on the MAXENT DSMs have shown to be excellent and accurate performance of an AUC value surpass 0.9 (Dou et al., 2021). Figure 4 and Table 4 show the results of jackknife tests. Figure 3 shows the response curves of the species in relation to the two main factors influencing the spatial distribution of each species. The results of Jackknife›s analysis showed that altitude, distance to Mediterranean Sea, distance to streams, and topography position index were the main factors influencing the distribution of these species.

Adequate habitats of *Pistacia atlantica* were distributed along the rivers and their relevance increases as the distance to the river decreases (DR <200m) in areas of altitude below 800. This corresponds well to the fact that *P. atlantica* mostly grow in water concentration areas (i.e., thalwegs) at an altitude of approximately 700 m (Benhassaini et al., 2007). Furthermore, altitude proven to be the most contributing variable with high gains especially to *Quercus ilex* and *Tetraclinis articulata* spatial distribution models with 55.3 and 67.1%, respectively.

Moreover, the maximum presence of *T. articulata* was limited to the altitude between 780 and 980 m, contrary to *Quercus ilex* which has a high probability of occurrence in areas higher than 1180 m elevation. This corresponds well to the fact that *Tetraclinis articulata* is a thermopile species (Quézel, 2002) in the big Atlas or belongs the study area; it only appears at 800 to 1000 meters altitude (Boudy, 1952). Alcaraz (1982) and Hadjadj-Aoul (1995) point out that at high altitudes *T. articulata* is sidelined by more cold-resistant species such as *Quercus ilex*. This altitudinal zonation is in full compliance with the observations of Achhal et al. (1980) and Quézel, Médail (2003).

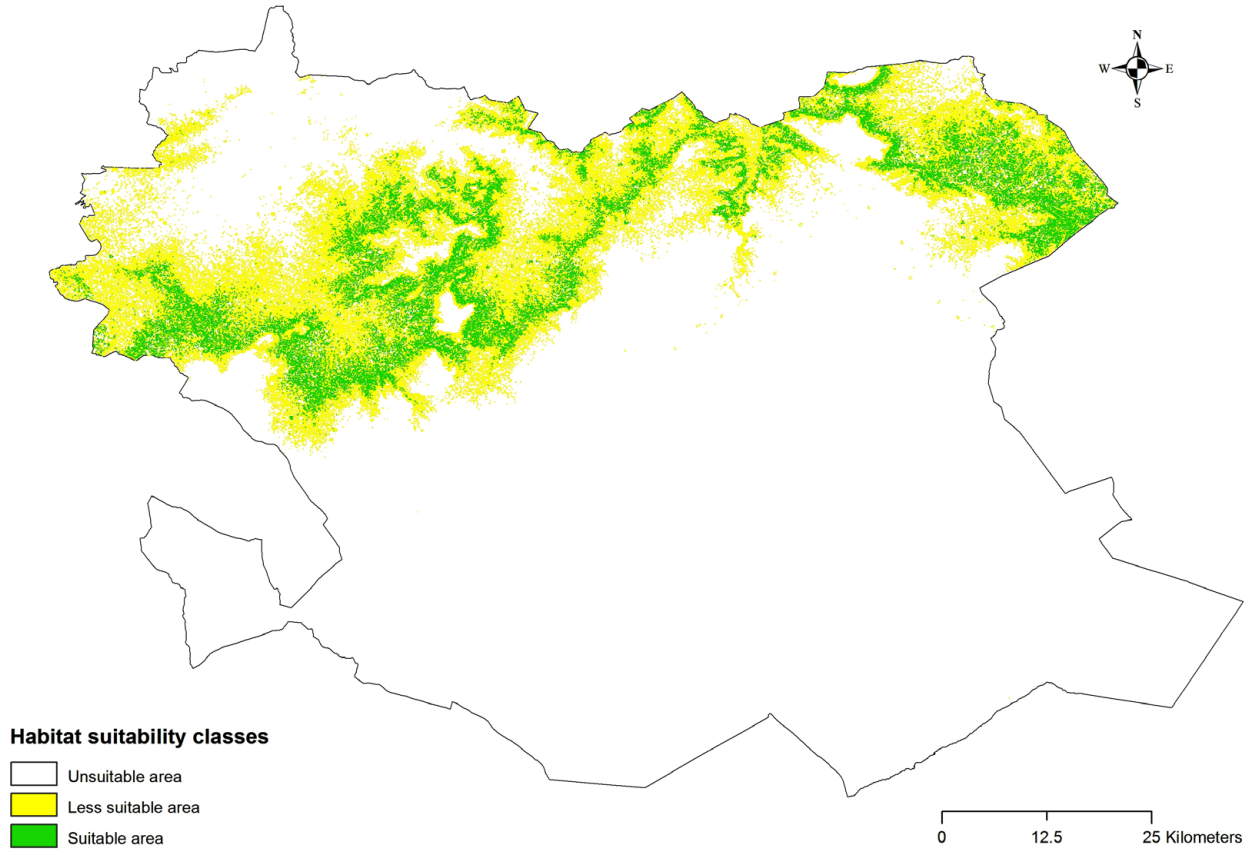


Fig. 6B. Potential habitat map of *Tetraclinis articulata*.

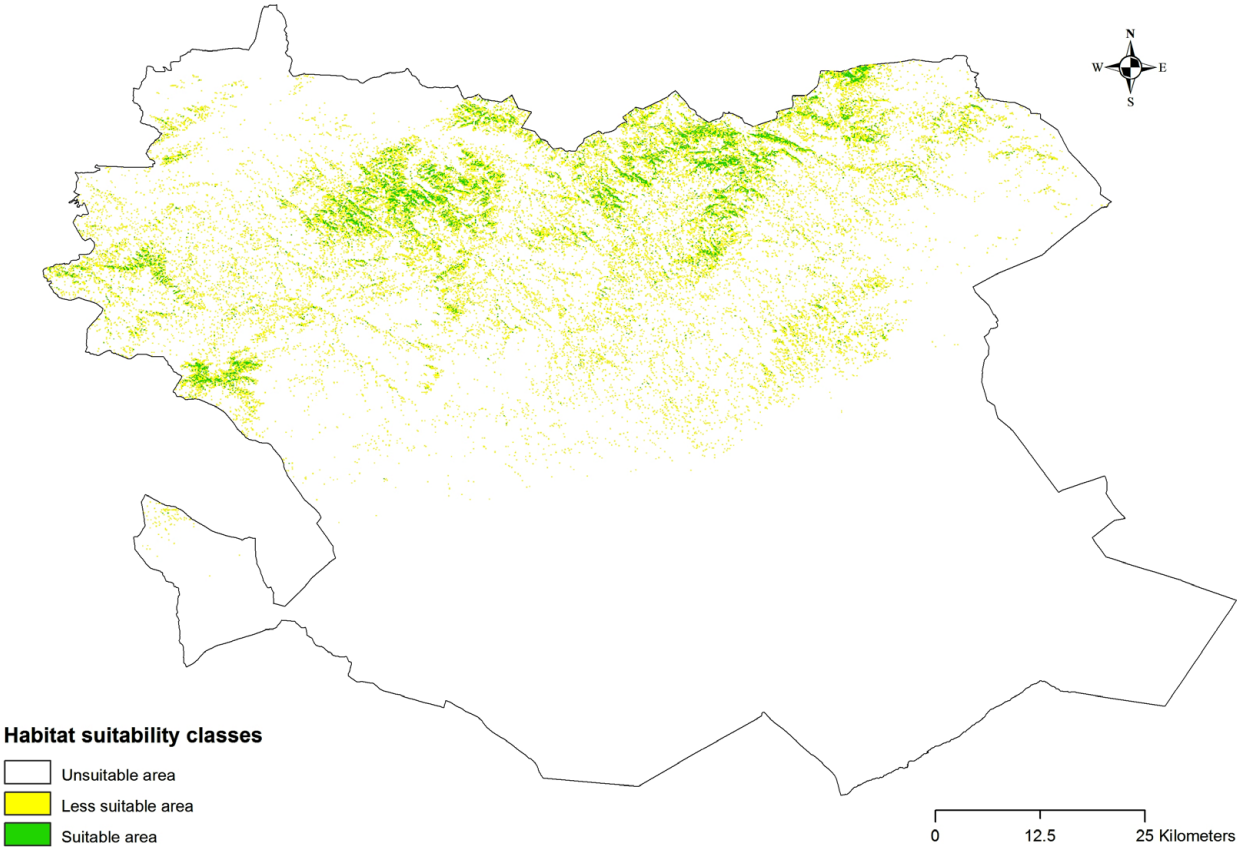


Fig. 6C. Potential habitat map of *Quercus faginea*.

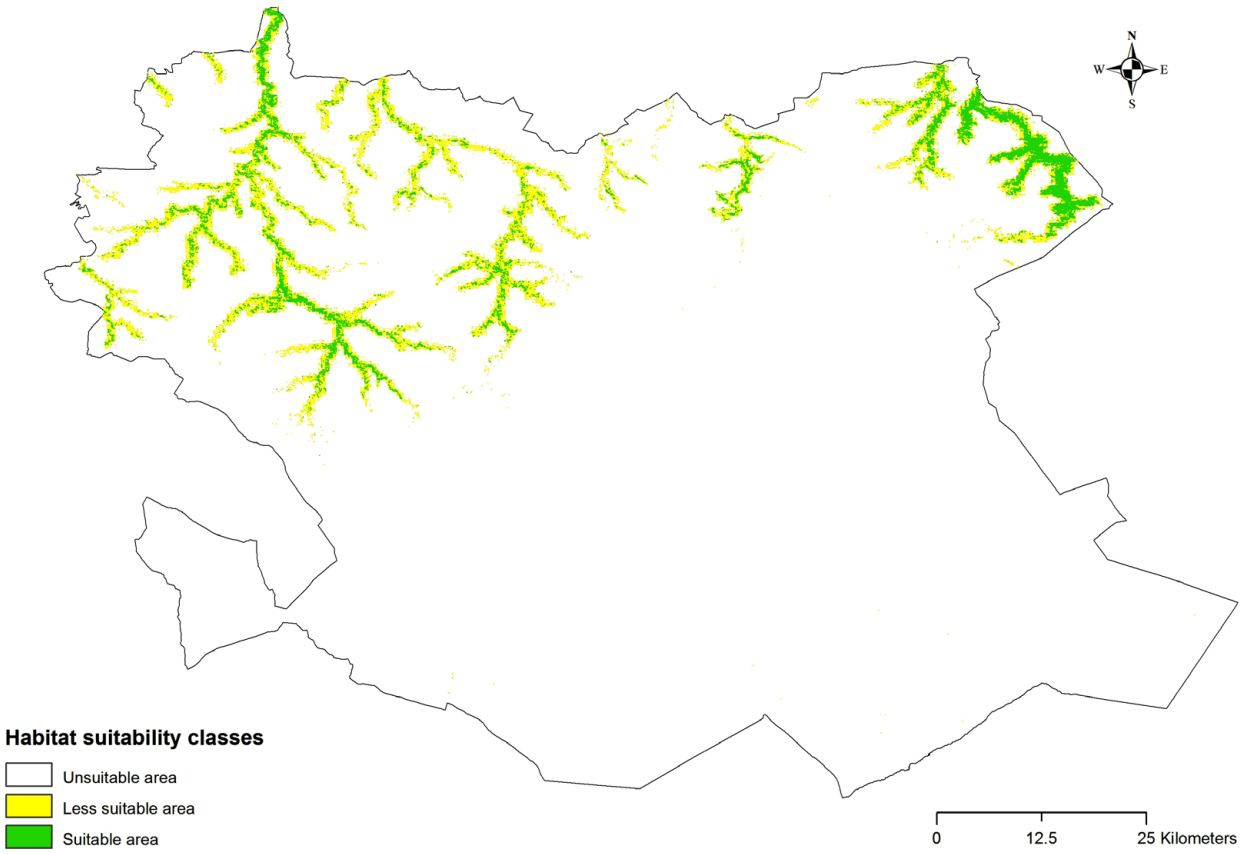


Fig. 6D. Potential habitat map of *Pistacia atlantica*.

The seemingly suitable habitats of *Q. faginea* appear to be highly fragmented, with highly suitable areas located mainly in the northern part of the region (Fig. 5), in mountain ranges and their suitability increases as the value of TPI is negative (represents the depressions such as valleys and gullies); this corresponds well to the fact that *Q. faginea* is encountered mainly in particular station conditions, humid ravines, valley bottoms, and shady slopes where a constant humidity reigns for a large part of the year (Achhal et al., 1980).

In our study and with the exception of *Pistacia atlantica* Desf., the distance from the sea was among the main factors influencing the distribution of the targeted species. This is mainly in the case of all the north of Algeria; distance from the sea among the factors that have a major influence on the spatial variability of precipitation (Laborde, 1993; Meddi, Hubert, 2003; Meddi et al., 2013), and there is a negative relationship between continentality and remoteness from the sea, which translates into a decrease in precipitation more than one distance from the sea coast (Mansour et al., 2020). This is in agreement with other studies, which have shown that both degrees of continentality and elevation are the two environmental factors that strongly modulate vegetation distribution (Nicolaci et al., 2014; Sanders et al., 2014; Ayache et al., 2020; Laala et al., 2021). This fits well with the fact that in the final model, the most suitable potential habitats for the four species were located in the northern parts of the region of Saida (Fig. 6 and Table 5).

Conclusion

In conclusion, the MAXENT models carried out as part of this research are able to predict with great accuracy the potential distribution of *Quercus faginea, Pistacia atlantica*, *Quercus ilex*, and *Tetraclinis articulata* in the Saida region. The topographic variables are proven to be very effective. Altitude, distance to Mediterranean Sea, distance to streams, and topography position index were the main explanatory variables. The high-resolution maps produced in this study allow the restoration of all the affected areas taking into account the species of origin and carrying out any reforestation programs at the local level.

References

Abolmaali, S.M.R., Tarkesh, M. & Bashari H. (2018). MaxEntmodeling for predicting suitable habitats and identifying the effects of climate change on a threatened species, Daphne mucronata, in central Iran. *Ecological Informatics*, 43, 116–123. DOI: 10.1016/j.ecoinf.2017.10.002.

Abrha, H., Birhane, E., Hagos, H. & Manaye A. (2018). Predicting suitable habitats of endangeredJuniperusprocera tree under climate change in Northern Ethiopia. *Journal of Sustainable Forestry*, 37(8), 842–853. DOI: 10.1080/10549811.2018.1494000.

Achhal, A., Akabli, O., Barbero, M., Benabid, A., M'hirit, A., Peyre, C., Quezel, P. & Rivas-Martinez S. (1980). A propos de la valeurbioclimatiqueetdynamique de quelques essences forestières au Maroc. *Ecol. Mediterr.*, 5, 211–249.

Agnew, M.D. & Palutikof J.P. (2000). GIS-based construction of baseline climatologies for the Mediterranean using terrain variables. *Clim. Res.*, 14(2), 115–127. DOI: 10.3354/cr014115.

Alcaraz, C. (1982). *La vég*étation de l'ouest *Algérien*. PhD Thesis, University of Perpignan.

Ayache, F., Santana, V.M. & Baeza M.J. (2020). Environmental and anthropogenic drivers of coniferous species distribution in Mediterranean drylands from North West Algeria. *Folia Geobot.*, 55(1), 15–27. DOI: 10.1007/s12224-020-09362-8.

Benhassaini, H., Mehdadi, Z., Hamel, L. & Belkhodja M. (2007). Phytoécologie de *Pistacia atlantica* Desf. subsp. *Atlantica* dans le Nord-Ouestalgérien. *Science et Changements Planétaires/Sécheresse*, 18(3), 199–205. DOI : 10.1684/sec.2007.0086.

Boudy, P. (1952). *Guide du forestieren Afrique du Nord*. Paris: La Maison Rustique.

Brague-Bouragba, N., Brague, A., Dellouli, S. & Lieutier F. (2007). Comparaison des peuplements de Coléoptères et d'Araignéesen zone reboisée et en zone steppique dans une région présaharienne d'Algérie. *C.R.Biol.,* 330(12), 923–939. DOI: 10.1016/j.crvi.2007.09.004.

Das, A., Nagendra, H., Anand, M. & Bunyan M. (2015). Topographic and bioclimatic determinants of the occurrence of forest and grassland in tropical montane forest-grassland mosaics of the Western Ghats, India. *PloS One*, 10(6), e0130566. DOI: 10.1371/journal.pone.0130566.

Djebbouri, M. & Terras M. (2019). Floristic diversity with particular reference to endemic, rare or endangered flora in forest formations of Saïda (Algeria). *International Journal of Environmental Studies*, 76(6), 990–1003. DOI: 10.1080/00207233.2019.1620541.

Dou, J., Yunus, A.P., Merghadi, A., Wang, X. & Yamagishi H. (2021). A Comparative Study of Deep Learning and Conventional Neural Network for Evaluating Landslide Susceptibility Using Landslide Initiation Zones. In F. Guzzetti et al. (Eds.), *Understanding and Reducing Landslide Disaste Risk* (pp. 215–223). Springer. DOI: 10.1007/978-3-030-60227-7_23.

Elith, J., Graham, C.H., Anderson., R.P., Dudík., M., Ferrier, S., Guisan, A., Hijmans, R.J., Huettmann, F., Leathwick, J.R., Lehmann, A., Li, J., Lohmann, L.G., Loiselle, B.A., Manion, G., Moritz, C., Nakamura, M., Nakazawa, Y., Overton, J.M.M., Townsend Peterson, A., Phillips, S.J., Richardson, K., Scachetti-Pereira, R., Schapire, R.E., Soberón, J., Williams, S., Wisz, M.S. & Zimmermann N.E. (2006). Novel methods improve prediction of species' distributions from occurrence data. *Ecography*, 29(2), 129–151. DOI: 10.1111/j.2006.0906-7590.04596.x.

Fourcade, Y., Engler, J.O., Rödder, D. & Secondi J. (2014). Mapping species distributions with MAXENT using a geographically biased sample of presence data: a performance assessment of methods for correcting sampling bias. *PloS One*, 9(5), e97122. DOI: 10.1371/journal.pone.0097122.

Giles, J.R., Peterson, A.T., Busch, J.D., Olafson, P.U., Scoles, G.A., Davey, R.B., Mathews Pound, J., Kammlah, D.M., Lohmezer, K.H. & Wagner D.M. (2014). Invasive potential of cattle fever ticks in the southern United States. *Parasites & Vectors*, 7(1), 189–189. DOI: 10.1186/1756-3305-7-189.

Guisan, A., Edwards, J. & Hastie T. (2002). Generalized linear and generalized additive models in studies of species distributions: setting the scene. *Ecol. Model.*, 157(2–3), 89–100. DOI: 10.1016/S0304-3800(02)00204-1.

Guisan, A. & Thuiller W. (2005). Predicting species distribution: offering more than simple habitat models. *Ecology Letters*, 8(9), 993–1009. DOI: 10.1111/j.1461-0248.2005.00792.x.

Hadjadj-Aoul, S. (1995). *Les peuplements du thuya de berbérieen Algérie: phytoécologieSyntaxonomie, potentialités sylvicoles*. PhD Thesis, University Aix-Marseille III. http://www.theses.fr/1995AIX30045.

Hamdi, L., Defaflia, N., Fehdi, C. & Merghadi A. (2020). InSAR Investigation on DRAA-Douamis Sinkholes in Cheria Northeastern of Algeria. In IGARSS 2020-2020 IEEE *International Geoscience and Remote Sensing Symposium* (pp. 1034–1037). IEEE. DOI: 10.1109/IGARSS39084.2020.9323835.

Hardlife, M., Henry, N., Paradzayi, T., Mpakairi, K.S. & Eliah G. (2020). Predicting the invasion of a southern African savannah by the black wattle (*Acacia mearnsii*). *J. For. Res.*, 31(5), 1995–2003. DOI: 10.1007/s11676-019-00975-0.

Hengl, T.& Reuter H.I. (2008). *Geomorphometry: concepts, software, applications*. Elsevier.

Khosravi, R., Hemami, M.R., Malekian, M., Flint, A. & Flint L. (2016). Maxent modeling for predicting potential distribution of goitered gazelle in central Iran: the effect of extent and grain size on performance of the model. *Tur. J. Zool.*, 40(4), 574–585. DOI: 10.3906/zoo-1505-38.

Kumar, S. & Stohlgren T.J. (2009). Maxent modeling for predicting suitable habitat for threatened and endangered tree *Canacomyrica monticola* in New Caledonia. *Journal of Ecology and the Natural Environment*, 1(4), 94–98. DOI: 10.5897/JENE.9000071.

Laala, A., Alatou, D. & Adimi A. (2021). Predicting potential habitat suitability of Quercus suber L. in Algeria under climate change scenarios. *Afr. J. Ecol.*, 59(4), 976–987. DOI: 10.1111/aje.12906.

Laborde, J.P. (1993). *Carte pluviométrique de l'Algérie du Nord à l'échelle du 1/500000*. Agence Nationale des Ressources Hydrauliques, projet PNUD/ALG/88/021, une carte avec notice explicative.

Lassueur, T., Joost, S. & Randin C.F. (2006). Very high resolution digital elevation models: Do they improve models of plant species distribution?. *Ecol. Model.*, 198(1–2), 139–153. DOI: 10.1016/j.ecolmodel.2006.04.004.

Lecours, V., Dolan, M.F., Micallef, A. & Lucieer V.L. (2016). A review of marine ggeomorphometry, the quantitative study of the seafloor. *Hydrology and Earth System Sciences*, 20(8), 3207–3244. DOI: 10.5194/hess-20-3207-2016.

Leempoel, K., Parisod, C., Geiser, C., Daprà, L., Vittoz, P. & Joost S. (2015). Very high-resolution digital elevation models: are multi-scale derived variables ecologically relevant?. *Methods in Ecology and Evolution*, 6(12), 1373–1383. DOI: 10.1111/2041-210X.12427.

Mansour, Z., Abderahmane, H. & Soraya R. (2020). Using Topographic and Geographic Terrain Characteristics for Mapping Annual Rainfall in the Tafna Watershed, Western Algeria. *International Journal of Water Resources and Arid Environments,* 9(1), 80–86. https://www.psipw.org/attachments/article/2054/7e.pdf

Meddi, M. & Hubert P. (2003). Impact de la modification du régime pluviométrique sur les ressources en eau du Nord-Ouest de l'Algérie. In *IAHS Publication* (pp. 229–235). Montpellier.

Meddi, M., Meddi, H., Toumi, S. & Mehaiguen M. (2013). Regionalization of rainfall in North-Western Algeria. *Geographia Technica*, 17(1), 56–69. http://www.technicalgeography.org/pdf/1_2013/07_1_2013.pdf

Merghadi, A., Yunus, A.P., Dou, J., Whiteley, J., ThaiPham, B., Bui, D.T., Avtar, R. & Abderrahmane B. (2020). Machine learning methods for landslide susceptibility studies: A comparative overview of algorithm performance. *Earth-Science Reviews*, 207, 103225. DOI: 10.1016/j.earscirev.2020.103225.

Mod, H.K., Scherrer, D., Luoto, M. & Guisan A. (2016). What we use is not what we know: environmental predictors in plant distribution models. *J. Veg. Sci.*, 27(6), 1308–1322. DOI: 10.1111/jvs.12444.

Nicolaci, A., Travaglini, D., Menguzzato, G., Nocentini, S., Veltri, A. & Iovino F. (2014). Ecological and anthropogenic drivers of Calabrian pine (*Pinus nigra* JF Arn. ssp. laricio (Poiret) Maire) distribution in the Sila mountain range. *iForest-Biogeosciences and Forestry*, 8(4), 497–508. DOI: 10.3832/ifor1041-007.

Pearson, R.G., Raxworthy, C.J., Nakamura, M. & Townsend Peterson A. (2007). Predicting species distributions from small numbers of occurrence records: a test case using cryptic geckos in Madagascar. *J.Biogeogr.*, 34(1), 102–117. DOI: 10.1111/j.1365-2699.2006.01594.x.

Phillips, S.J., Anderson, R.P. & Schapire R.E. (2006). Maximum entropy modeling of species geographic distributions. *Ecol. Model.*, 190(3–4), 231–259. DOI: 10.1016/j.ecolmodel.2005.03.026.

Phillips, S.J. & Dudík M. (2008). Modeling of species distributions with Maxent: new extensions and a comprehensive evaluation. *Ecography*, 31(2), 161–175. DOI: 10.1111/j.0906-7590.2008.5203.x.

Quézel, P. (2002). *Réflexions sur l'évolution de la flore et de la végétation au Maghreb Méditerranéen*.Vol. 1. Paris: Ibis Press.

Quézel, P. & Médail F. (2003). *Ecologie et biogéographie des forêts du bassinMéditerranéen*. Vol. 572. Paris: Elsevier.

Sanders, T.G., Pitman, R. & Broadmeadow M.S.(2014). Species-specific climate response of oaks (Quercus spp.) under identical environmental conditions. *iForest-Biogeosciences and Forestry*, 7(2), 61–69. DOI: 10.3832/ifor0911-007.

Sharma, S., Arunachalam, K., Bhavsar, D. & Kala R. (2018). Modeling habitat suitability of Perillafrutescens with MaxEnt in Uttarakhand—A conservation approach. *Journal of Applied Research on Medicinal and Aromatic Plants*, 10, 99–105. DOI:10.1016/J.JARMAP.2018.02.003.

Society for Ecological Restoration International Science & Policy Working Group (2004). The SER International Primer on Ecological Restoration.https://cdn.ymaws.com/www.ser.org/resource/resmgr/custompages/publications/ser_publications/ser_primer.pdf

Terras, M. (2011). *Typologie, cartographie des stations forestières et modélisations des Peuplements forestiers. Cas des massifs forestiers de la wilaya de Saida (Algérie)*. PhD Thesis, University of Tlemcen. http://dspace.univ-tlemcen.dz/handle/112/8446.

Zhang, L., Liu, S., Sun, P., Wang, T., Wang, G., Wang, L. & Zhang X. (2016). Using DEM to predict *Abiesfaxoniana* and *Quercusaquifolioides* distributions in the upstream catchment basin of the Min River in southwest China. *Ecological Indicators*, 69, 91–99. DOI: 10.1016/j.ecolind.2016.04.008.

Zouidi, M., Borsali, A.H., Allam, A. & Gros R. (2019). Microbial activities and physicochemical properties of coniferous forest soils in two forest areas (arid and semi arid) of western Algeria. *Bosque* (*Valdivia*), 40, 163–171. DOI: 10.4067/S0717-92002019000200163.